NASA Innovative Advanced Concepts

Swarm Flyby Gravimetry

Completed Technology Project (2014 - 2015)

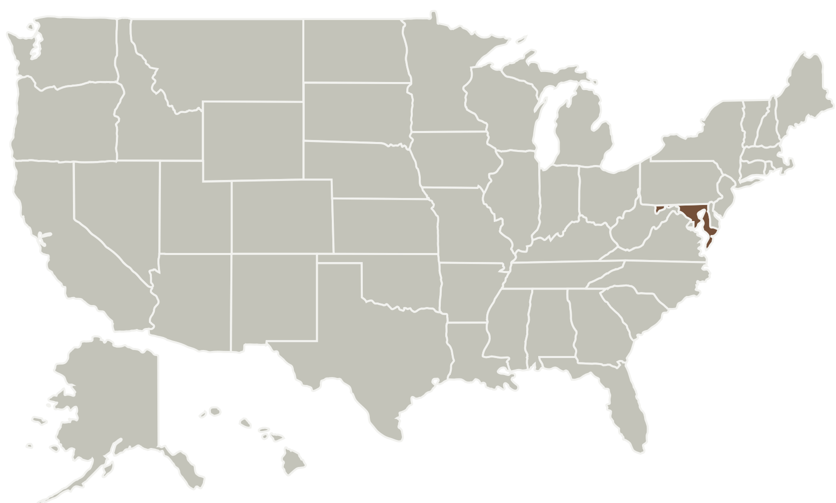
Project Introduction

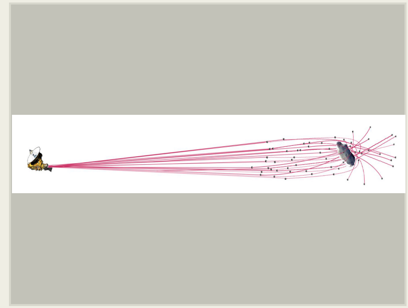
By tracking those probes, we can estimate the asteroid's gravity field and infer its underlying composition and structure. This approach offers a diverse measurement set, equivalent to planning and executing many independent and unique flyby encounters of a single spacecraft. The resulting dataset can yield a global model of the body's mass distribution and reveal unique aspects of the body's interior structure that are otherwise unobservable. This concept offers the possibility of achieving new scientific measurements that extend our understanding of our solar system, benefit human spaceflight, and support planetary protection. The concept consists of a spacecraft releasing a swarm of small, low-cost probes during a flyby past an asteroid or comet.

Anticipated Benefits

This study describes a new technology for discerning the gravity fields and mass distribution of a solar system small body, without requiring dedicated orbiters or landers. Instead of a lander, a spacecraft releases a collection of small, simple probes during a flyby past an asteroid or comet. By tracking those probes from the host spacecraft, one can estimate the asteroid's gravity field and infer its underlying composition and structure. This approach offers a diverse measurement set, equivalent to planning and executing many independent and unique flyby encounters of a single spacecraft. This method offers a feasible, affordable approach to enabling or augmenting flyby science.

Primary U.S. Work Locations and Key Partners





Swarm Flyby Concept Image

Table of Contents

Organizations Performing Work	Role	Type	Location
Johns Hopkins University Applied Physics Laboratory(JHU/APL)	Lead Organization	R&D Center	Laurel, Maryland
Johns Hopkins University	Supporting Organization	Academia	Baltimore, Maryland

Primary U.S. Work Locations
Maryland

Project Transitions

July 2014: Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Johns Hopkins University Applied Physics Laboratory (JHU/APL)

Responsible Program:

NASA Innovative Advanced Concepts

Project Management

Program Director:

Jason E Derleth

Program Manager:

Eric A Eberly

Principal Investigator:

Justin A Atchison

Co-Investigators:

Andrew Rivkin
Katherine Stambaugh

March 2015: Closed out

Closeout Summary: This study describes a new technology for discerning the gravity fields and mass distribution of a solar system small body, without requiring dedicated orbiters or landers. Instead of a lander, a spacecraft releases a collection of small, simple probes during a flyby past an asteroid or comet. By tracking those probes from the host spacecraft, one can estimate the asteroid's gravity field and infer its underlying composition and structure. This approach offers a diverse measurement set, equivalent to planning and executing many independent and unique flyby encounters of a single spacecraft. This report assesses a feasible hardware implementation, derives the underlying models, and analyzes the performance of this concept via simulation. In terms of hardware, a small, low mass, low cost implementation is presented, which consists of a dispenser and probes. The dispenser contains roughly 12 probes in a tube and has a total size commensurate with a 6U P-Pod. The probes are housed in disc shaped sabots. When commanded, the dispenser ejects the top-most probe using a linear motor. The ejected probe separates from its sabots and unfolds using internal springs. There are two types of probes, each designed for a particular tracking modality. The reflective probe type, tracked by a telescope, unfolds to form a diffusely reflective sphere. The retroreflector probe type, tracked by a lidar, unfolds to form a corner-cube retroreflector assembly. Both types are designed to spherical so that their attitude doesn't affect the spacecraft's tracking performance. This analysis indicates that the point-mass term of small bodies larger than roughly 500 m in diameter can be observed from a host spacecraft that tracks locally deployed probes throughout a flyby to an uncertainty of better than 5%. The conditions by which this measurement is possible depends on the characteristics of the asteroid (size, type), the flyby velocity, and the type of tracking available (angles-only or angles + ranging). For most encounters, a few (1-3) well placed probes can be very effective, with marginal improvement for additional probes. Given realistic deployment errors, an encounter may require roughly 10-12 probes to ensure that 1-3 achieve their target. Long duration tracking of probes flying by large asteroids (>5 km diameter) can sometimes provide observability of the gravity field's first spherical harmonic, J2. In summary, this method offers a feasible, affordable approach to enabling or augmenting flyby science.

Images

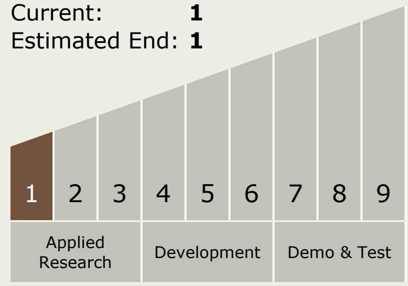
Swarm Flyby Concept Image
Swarm Flyby Concept Image
(https://techport.nasa.gov/image/102234)

Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html

Technology Maturity (TRL)

Start: **1**
Current: **1**
Estimated End: **1**



Technology Areas

Primary:

- TX11 Software, Modeling, Simulation, and Information Processing
  └ TX11.4 Information Processing
    └ TX11.4.3 Semantic Technologies

Target Destinations

Others Inside the Solar System, Foundational Knowledge